

# Avoiding Power Transformer's Failures During Transmission

## Course Description:

This course covers the theory, operation, maintenance and testing of power transformers and auxiliary equipment. Topics included are transformer fundamentals, transformer ratings, transformer cooling, nitrogen gas systems and insulation systems. The source concludes with in-depth discussions on transformer testing techniques. This course is applicable to technicians and engineers who need a sound understanding of power transformer operation and maintenance.

Students will learn safe and proper maintenance and testing procedures on pad-mounted, power transformers. The course covers transformers used in commercial and industrial power distribution systems, including oil and dry-type units. Larger power transformers used in utility applications are also covered.

Load and no-load tap changer maintenance, ac and dc testing, routine inspections and oil sampling and testing are covered in detail. Students will learn how to perform routine oil tests, and understand how to perform the major tests that are required. A variety of electrical test equipment from various manufacturer's will be discussed.

## Course Objective

Upon completion of this course, the participant should be able to:

- Explain the basic operation of a transformer.
- Discuss turns ratios and calculate terminal voltage and current.
- Discuss terminal markings and various single phase and three phase wiring schemes. (WYE vs DELTA).
- Explain how to perform a polarity test on a potential transformer.
- Discuss the electrical testing performed on transformers such as insulation resistance testing, excitation and power factor testing.
- Discuss the various tests performed on insulating oil.
- Identify all methods for oil analysis and diagnosis
  - Learn and professionalize their knowledge about electrical and mechanical testing.
  - Learn how to plan a transformer assessment program
  - Learn how to plan a maintenance program against the reliability index required

## Who Should Attend?

Field and shop technicians, field engineers, supervisors and others responsible for the testing and maintenance of power transformers rated 750kVA to 500MVA and 4.16kV to 500kV

This program is designed for Operation, Maintenance and Condition Monitoring Engineers those working in Electrical System. High Caliber Supervisors are also recommended to attend this program.

**Course Duration:** Five days

## Course Outlines:

- **Transformer Principles**



- **Vector Diagrams**
- **Transformer Classifications**
- **Magnetizing Circuits**
- **Transformer Construction (Construction)**
- **Cooling**
- **Tap Changers**
- **Transformer Connections**
- **Transformer Maintenance**
- **Transformers and Relaying**

## **Module (01) Transformer Fundamentals**

- 1.1 Why Transformer?
- 1.2 Transformer Types and Categories
- 1.3 Transformer Design and Construction
- 1.4 The Insulation System
- 1.5 Transformers Oil Purpose.
- 1.6 Magnetic theory of operations
- 1.7 Transformer Losses (magnetic and copper)
- 1.8 Transformer Current (excitation, no load and inrush)
- 1.9 Calculation of Transformer Losses  
(Core Losses and no load)
- 1.10 Transformer Protection  
(Electric and Mechanical)
- 1.11 How to specify a Transformer?

## **Module (02) Insulation Oil**

- 2.1 Why we use Insulation Oil?
- 2.2 Oil Properties Specification
- 2.3 Oil Handling and Storage
- 2.4 Health and Environmental Care Procedures for Insulation Oil
- 2.5 Oil Sampling Methods for break down and chemical tests
- 2.6 Oil Electric Tests (Dielectric Breakdown Test/ Power Factor Test, etc)
- 2.7 Oil Chemical Test (Acid number, Furans, Oxygen, and Moisture)

## **Module (03) Oil Analysis Oriented Diagnosis**

- 3.1 Transformer Diagnostics Procedures
- 3.2 Dissolved Gas Analysis
- 3.3 Transformer diagnosis using Individual and Total dissolved key gas concentrations
- 3.4 Diagnosing The Problem using Dissolved Gas
- 3.5 Analysis and the Duvall triangle & expertise.
- 3.6 Needed Oil Physical/chemical tests
- 3.7 Annual Transformer Oil Tests
  - Dielectric Strength
  - Interfacial Tension (IFT)
  - Acid Number
  - Furans
  - Oxygen
  - Oxygen Inhibitor



#### Additional Tests on Insulation

- Insulation Power Factor Test
- Capacitance Tests
- Excitation Current Test
- Bushing Tests
- Percent Impedance/Leakage Reactance Test
- Sweep Frequency Response Analysis Tests

### **Module(04) Mechanical & Electrical Oriented Diagnosis**

#### 4.1 Visual inspection

- Temperature indicators online
- Temperature indicators offline
- Conservator
- Conservator breather
- Nitrogen
- Oil leaks
- Pressure relief device
- Oil pumps
- Fans and radiators
- Buchholz relay.
- Sudden pressure relay
- Bladder failure relay

#### 4.2 Infrared temperature analysis

- IR for transformer tanks
- IR for surge arresters
- IR for bushings
- IR for radiators and cooling systems

#### 4.3 Corona scope scan

#### 4.4 Ultrasonic and sonic fault detection

#### 4.5 Vibration analyses

#### 4.6 Turns ratio test

#### 4.7 Dc winding resistance measurement

#### 4.8 Core Insulation Resistance

#### 4.9 Inadvertent Core Ground test

#### 4.10 Estimate of Paper Deterioration (Online)

- Co<sub>2</sub> and co accumulated total gas values
- Co<sub>2</sub>/co ratio
- Furans

#### 4.11 Estimate of paper deterioration (offline)

- Degree of polymerization (DP)
- Process

#### 4.12 Internal Inspection.

#### 4.13 Transformer Bore Scope

#### 4.14 Tr. Operating History

### **Module (05) Transformer Condition Assessment**

#### 5.1 Condition Indicators & Transformer Condition Index

#### 5.2 TIER 1 - Inspections, Tests, Measurements

- Condition Indicator 1 – Insulating Oil Analysis
- Condition Indicator 2 – Power Factor and Excitation

#### Current Tests

- Condition Indicator 3 – Ops & Maintenance History
- Condition Indicator 4 – Age

#### 5.3 TIER 2 - Inspections, Tests, Measurements

- Test T2.1: Turns Ratio Test



- Test T2.2: Short Circuit Impedance Tests
  - Test T2.3: Core-to-Ground Resistance Mega Ohmmeter Tests
  - Test T2.4: Winding Direct-Current Resistance Measurements
  - Test T2.5: Ultrasonic and Sonic Fault Detection Measurements
  - Test T2.6: Vibration Analysis
  - Test T2.7: Frequency Response Analysis (FRA)
  - Test T2.8: Internal Inspection
  - Test T2.9: Degree of Polymerization
- 5.4 Tr. Condition Assessment Methodology  
5.5 Tr. Condition Assessment Summary Form  
5.6 Maintenance-reliability matrix.

### **Module (06) Tr. Protection for Failure reduction**

- 6.1 Transformer Heat damage curve for frequent and non-frequent faults.
- 6.2 Protection by fuses located at the high side (limitations and selection)
- 6.3 Protection by Over Current Relays
- 6.4 The Inrush Current of Power Transformers and saturation of current transformers and their influence on the protection systems.
- 6.5 Differential Protection (range and error levels)
- 6.6 Mechanical Protection
- 6.7 Pressure Detector
- 6.8 Temperature Detector
- 6.9 Buchholz Relay